2. Record keeping and reporting differed between the contract and USACE dredgers

In addition to the contract dredge having a detailed disposal pattern specified for it by the District, the contractor was also required to provide a report to the District identifying the precise disposal locations as determined by a real-time satellite tracking system . Although similar data were collected routinely by the USACE dredge, there was no requirement that these data be supplied to the District (The data were available however, and were provided immediately to the Review Team upon request.). This highlights the need for better feedback between District managers and the vessel. If disposal tracks for the USACE dredge had been made available to District personnel in a routine and timely manner, the focused disposal being conducted by the USACE dredge could possibly have been recognized and monitored, and perhaps corrected, before excessive mounding resulted. The Review Team recommends that the same kinds of information and reporting requirements apply to both contract and USACE dredging and disposal operations at MCR, that those records be turned into the District frequently during operations, and that District personnel managing the MCR O&M project closely and expeditiously review those records in order to make any necessary adjustments in a timely manner, to best achieve the disposal site management goals.

3. Frequency of disposal site surveys

Condition surveys were conducted very frequently (approximately every 48 hours) as part of the contractor's dredging and disposal operations at Site E. However, such frequent surveys were not conducted as part of the operation of the USACE dredge. The first operational condition survey of the eastern portion of Site E in which the USACE dredge was placing material in 2001 did not occur until 30 June, nearly a full month after disposal there had begun. By this time, approximately 900,000 cubic yards of dredged material had been discharged into the easternmost portion of the zone. Further, the results of this initial condition survey were not reviewed by District staff and converted into the "difference plots" used to monitor for mounding (as defined by the District's interpretation of the Settlement Agreement) for another twelve days (At the time, only one District employee was capable of generating these plots; that employee did not receive the initial survey results immediately, and was unavailable when they were finally provided.). Therefore, spatially focused disposal continued in this area for several days after the initial survey occurred, adding additional sediment before District staff had the information to take appropriate site management action (see Figure 2 and text box). The length of time that elapsed between condition surveys, and the time it took for District staff to generate the "difference plots" from the initial survey, contributed to the mounding in the eastern portion of Site E, and subsequently to the urgency in issuing the Record of Decision. More frequent condition surveys right from the beginning of disposal operations could have detected the focused mounding that was occurring before it became severe. The Review Team recommends that ways to obtain more frequent surveys in the *Essayons* disposal areas (like those conducted every 48 hours for the

contractor's operation) be explored; that the frequency increase especially whenever it is known that triggering conditions are approaching; and that the District increase its capacity for rapidly preparing difference plots (if these will continue to be relied upon) by either training additional staff or obtaining contractor support. To avoid undue cost increases, advantages and disadvantages of requiring the contract dredger's survey vessel

Summary of Surveys, Reports, and Key Events for Summer 2001 at Disposal Site E

Essayons disposed of all material from June to July 15 in the southeastern part of Site E. By end of June 900,000 cy dumped at Site E.

- June 30 Survey first detected mounding above the 5 foot threshold in eastern portion of Site E. Report July 12.
- July 19 survey detected additional mounding.
- July 30 Report and notification to Agencies on July 19 survey with differences plots, which indicated site exceedances up to 12 feet.
- *Essayons* was moved off site on July 14 although did use western portion of site July 30 – August 3.
- July 31 survey. Report on August 3rd provided notification that a 9 foot mound still existed although some erosion had occurred. The management option of dredging was identified.
- August 7 *Miss Brittany* sinks.
- August 9 notification of mound still exceeding 5 foot threshold and options of dredging becomes more apparent. Estimate of 200,000 cy at Site E above 5 foot limit.
- August 9-13 upper level management decision to dredge with minimal consultation with EPA – draft ROD and e-mails were sent to EPA. There appears to be some misunderstanding of site authority at Site E.
- August 13 Survey and August 14 Report which did not show substantial change.
- August 15 ROD formalized.
- August 16-20 *Essayons* dredged at Site E1 and removed 193,000 cy and redeposited in Site F.
- August 27 Survey shows mound removal at eastern portion of Site E.

to regularly submit soundings for all active disposal areas should be considered.

D. Management of Site E

In the Review Team's opinion, management of Site E should focus on balancing the goals of keeping dredged material in the near shore zone against the need to *not unacceptably increase risks* to vessels transiting the area (in contrast to a hypothetical goal of *providing for* vessel safety). Peacock Spit has been undergoing substantial long-

term erosion throughout the last century (Figure 10). It is unlikely that erosion of the Spit or the up-coast shoreline could be completely eliminated even if all the sand dredged for MCR O&M were to be placed at Site E. However, any sand placed there (and at the Jetty site) will help to retard the *rate* of sand loss from the system. At the same time, it is unlikely that even complete elimination of the use of Site E would substantially reduce existing risks to vessels transiting the area, because Peacock Spit would continue to exert a predominating influence on wave climate there for decades to come.

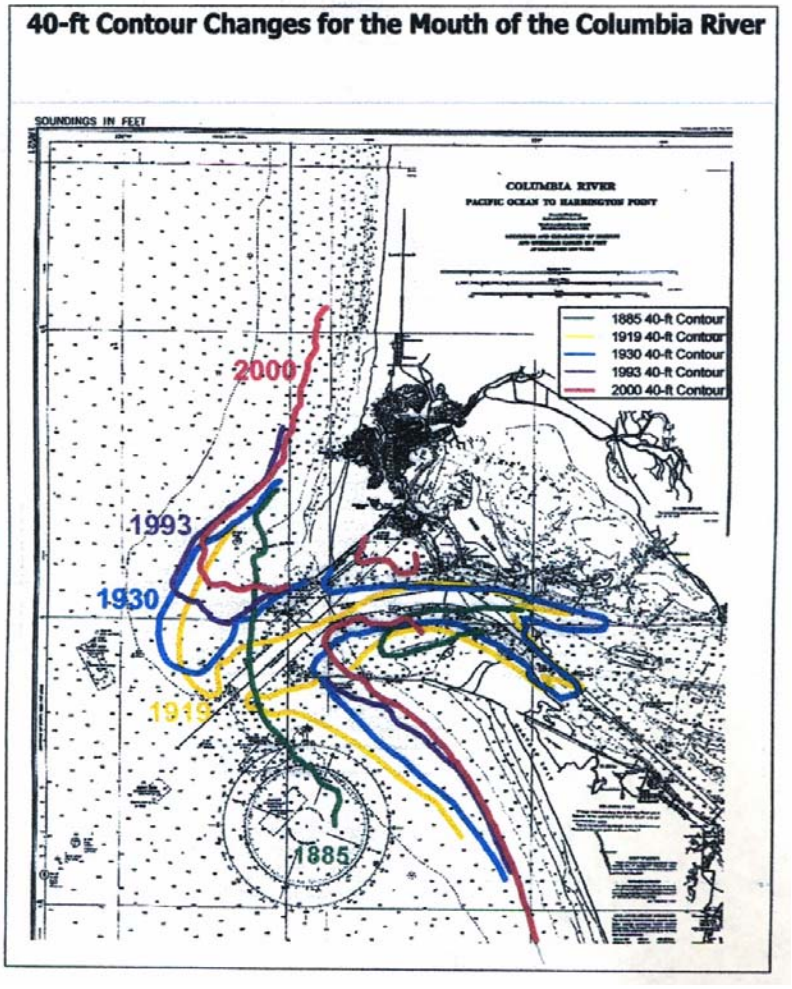

Figure 10. Historical erosion trends of Peacock Spit.

The parallel goal of minimizing potential seasonal impacts to Dungeness crab is at odds with both of the above, primary goals. Potential crab presence in the deeper, western portion of Site E has led to a restriction on disposal there after August 15. This ensures that even more emphasis must be placed on the smaller, shallower eastern portion of the site in order to meet disposal needs (if as much material as possible is to be kept in the littoral system). This eastern portion of the site is, in turn, where the most focused mounding has occurred, and has resulted in perceptions about negative impacts to navigation safety. If the entire site were available longer, there would be more flexibility

to manage the site in such a way that retention of sand in the littoral system could be maximized, and at the same time mounding effects minimized.

In order to place the maximum amount of sand at Site E for dispersion to the near shore zone without unreasonably increasing risks to vessels transiting the area, the District and EPA Region 10 must actively manage the site in accordance with site use parameters or standards developed specifically to address these issues. (The Settlement Agreement imposed one standard on site use, but the specific standard it uses, or at least its interpretation/implementation, does not necessarily relate directly to the site management goal as discussed in a later section) . In particular, any measurement or indicator of risk to vessels transiting the Site E area must reflect the reality that Site E lies immediately adjacent to (essentially on the south shoulder of) the existing, shallower, Peacock Spit. In other words, vessels transiting Site E south to north also must transit Peacock Spit. Mounding due to dredged material placement at Site E is highly unlikely to be the driving risk factor for vessels transiting this area unless and until that mounding is so severe that Site E effectively becomes the "high spot" of Peacock Spit itself along the transit route (The provisions of the Settlement Agreement indirectly ensure this would not happen, but other more meaningful methods for achieving the same goal could also be devised. See Wave Modeling Section.).

The Review Team believes that recent management of Site E has been getting out of balance. The District's interpretation and implementation of the Settlement Agreement is potentially jeopardizing its ability to accomplish the basic mission of maintaining the federal navigation channel at the MCR, even though there has been no apparent real or substantial increase of risk to vessels. As described below, the Review Team believes that Site E can be managed differently, and can probably accept more dredged material, while remaining in full compliance with the Settlement Agreement and without unacceptably increasing risks to vessels.

1. Site E Management Objectives and the MMP

As noted earlier, there is limited capacity at the other available disposal sites in the vicinity of the MCR. Therefore, Site E is presently critical to the District's mission of maintaining the federal navigation channel at the MCR. Site E also represents the primary means by which sand dredged from the navigation channel can be managed for the ongoing objective of retaining it in the near shore littoral system. At the same time, Site E is in an area widely known to be one of the most hazardous anywhere in the U.S. for vessel movement. It is also in or adjacent to a particularly heavily used and high value resource area. For these reasons Site E is already (and appropriately so) the most intensively managed ODMDS in the District.

The most up-to-date version of the MMP is the appropriate document to look to for particular management objectives, monitoring approaches, monitoring "triggers", and specific management actions to be considered based on monitoring results.

The 1998 MMP does provide a good general discussion of:

- the need for clear and specific management objectives;
- the benefits of tiered monitoring, and the role of performance predictions and hypothesis testing in the monitoring program;
- the need to identify evaluation questions and monitoring-based "triggers" for management action; and
- the need to identify a range of management actions that can be considered.

The MMP discusses each of these needs for the MCR sites. However, the information presented is not sufficiently detailed to serve as an adequate guide for the kind situation that arose at Site E in 2001.

The first of the MMP's Management Practices (page 1-10) states, "*Dredged material will be distributed between sites to reduce the potential for mounding. Alternate sites can be used if sea conditions, traffic, or other uses make one of the sites undesirable.*" But the assumption behind even this first management practice is not completely valid: even though Sites A and B were deactivated years earlier, the range of alternative sites actually available for routine use is not reflected in the MMP.

The MMP has also not been updated to reflect the requirements of the Settlement Agreement, which was finalized several months after the MMP was prepared. For example, it is unclear whether the Settlement Agreement supersedes the action triggers and management responses listed in Table 2-1 of the MMP. This table lists the 5-foot depth change (that has continued to be used at Site E) as the action trigger. However, it specifies that this depth of mounding must occur over 50 percent of the site for two years in order to trigger a management response. This does not appear to be the same "trigger" that led to the "re-dredging" decision in 2001, even though the Settlement Agreement does not appear to impose an alternate "trigger" (or any specific "action").

Finally, the 1998 MMP does not clearly reflect the importance now placed on reducing the rate of long-term erosion of Peacock Spit, and retaining sand in the near shore littoral system as required by the State of Washington's Water Quality Certification. Instead, the MMP (page 1-9) states, "*The primary management concern at the Columbia River ODMDS is to avoid mounding at the sites. Significant and persistent mounding can result in adverse wave conditions causing a potentially hazardous situation to navigation. A secondary concern is the potential for sediment to migrate back into the navigation channel.*" There is little or no mention of Peacock Spit, the littoral system, or the State of Washington's beneficial use requirement anywhere in the MMP. We recommend updating the 1998 MMP to reflect the current situation, as well as to provide necessary detail currently lacking (see "Need to Update the MMP" below).

2. Settlement Agreement

In 1998, plaintiffs including the Columbia River Crab Fisherman's Association (CRCFA) challenged the temporary expansion of Site E (and of Site B). The parties reached a Settlement Agreement in June 1998 (supplemented in September 1998)

allowing these sites to continue to be used under certain conditions. In particular, disposal cannot occur in the western 5000 feet of the Site E expansion area after August 15 in any year (to minimize impacts to crab that may be in the area after that time), and the USACE must "*make every effort in their disposal of dredged material at Site E to avoid disposal in a way that contributes to wave amplification greater than 10 percent.*" However, the Settlement Agreement also states, "*Nothing in this Stipulation affects, limits, or prevents … disposing dredged material within ODMD Sites B, E and F as designated in 1983 … (or) within the inner portion of expanded ODMD Site E*" (i.e., management of the original "102" Site E is not affected). According to an internal memorandum (U.S. Army Engineer District, Portland. 1998), USACE agreed to continuation of these restrictions because adequate short-term capacity existed (through the 2000 dredging season only), using all disposal sites available, to fully meet the maintenance requirements of the MCR's federal navigation channel. The Settlement Agreement's stipulations expire when the USACE's "103" site expansions expire in July 2002, and in any event they do not necessarily extend to management of new disposal sites designations that may occur in the future.

3. Recent Site Management Limitations Based on the Settlement Agreement

In the Review Team's opinion, several aspects of the Settlement Agreement, its conservative implementation by the District, and the language used in the "re-dredging" Record of Decision (ROD) have adversely and perhaps unnecessarily affected both site management and public perception regarding Site E.

The Settlement Agreement's "10 percent change" standard. The "10 percent change" standard in the Settlement Agreement apparently arose from the particular computer model being used by the District ("RCPWAVE") to predict potential wave amplitude changes. The 10 percent value was reportedly considered to be akin to the "noise level" of the model (in other words, above this model-predicted level some degree of real change was likely). An apparently tacit assumption was that this equated to an indicator of "no discernable change." Use of the 10 percent standard therefore effectively reflects a conservative "precautionary approach" to site management, whereby any degree of discernable change in wave amplitude is considered undesirable. However, it is a major leap to connote that an indicator of "any discernable change" is also an indicator of an actual "impact" (i.e., that an increased risk to vessels transiting the area would in fact result from this degree of change). It is a similarly major leap to conclude the inverse: that no measurable change due to disposal at Site E means the area is generally *safe* for vessel transit. Either conclusion is likely to be erroneous because of the overwhelming influence of the adjacent Peacock Spit on the area's wave climate, whether or not any material is disposed at Site E.

The District's estimate of mound height that could cause a 10 percent change. At different water depths, different mound heights are required to create a 10 percent change in amplitude for the same design wave. Site E ranges in depth from approximately 45-70 feet. However, a single factor (5-foot change in bottom depth) was used for simplicity as the indicator of whether mounding, at any depth, could result in a 10 percent change in

wave amplitude. This factor was felt to be convenient to track[1], and was used to help determine whether the computer wave model should be run using the actual bathymetric data. However, there was no particular definition of what kind of exceedance should necessarily trigger further management action (e.g., how much above the 5-foot trigger, over how large an area, and for what period of time?), or what kinds of management actions would be triggered. In any event, the Settlement Agreement did not mention the 5-foot value, or any other particular indicator. Therefore other approaches could have been followed. For example, we note the same actual wave amplitude would result from a 10-foot mound at an original bottom depth of 60 feet (i.e., with a mound crest at 50 feet) as from a 20-foot mound at an original bottom depth of 70 feet (also with a mound crest at 50 feet). The *location* of the peak wave amplitude could be slightly different, but the peak wave amplitude itself would be similar. And that peak wave amplitude would still be less than that caused by the much larger and shallower feature immediately to the north – Peacock Spit. In reality, dredged material deposited at the sloping Site E does not represent a discrete mound, but rather a relatively minor broadening of the existing southern shoulder of Peacock Spit.

The computer model used to predict whether the 10 percent change standard would be exceeded. On several occasions when bathymetric surveys showed that the "trigger" of a 5-foot change in bottom depth had been exceeded, the District ran a computer model to predict possible wave amplitude changes. However, the Settlement Agreement does not mandate this particular computer model be used. Other models available today and considered to be more realistic (e.g., "STWAVE") could provide a more accurate picture of wave changes (see Wave Modeling discussion, below). Under certain conditions, use of this more realistic model might have indicated that mounding at Site E was not "out of standard" relative to the Settlement Agreement, and re-dredging (or indeed any other management action) might not have seemed as urgent.

The "re-dredging" ROD. The ROD language unfortunately seemed to reinforce the connotations and tacit assumptions reflected in the Settlement Agreement and the District's conservative implementation of it. In particular, the ROD solidified the perception that *any* mounding over the management target of 5 feet was "excessive" (in contrast to the "Action Trigger" published in the MMP that was ostensibly still in force). Furthermore, the ROD noted the District's intent to re-dredge, but provided no discussion of other potential alternatives (except "no action"). The Settlement Agreement does not mandate re-dredging, or in fact any particular management action, if the 10 percent "standard" is exceeded.[2] Unfortunately, both the language of the ROD and the fact that

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1 However, we note that use of this factor (rather than, for example, a target bottom depth that could be read directly from the condition surveys) contributed to the mounding in 2001, due to the delay before the "difference plots" used to depict this factor could be prepared.

2 In fact, the Settlement Agreement states, "Nothing in this Stipulation affects, limits, or prevents" the USACE from disposing material within the original, EPA designated "102" area of Site E. This is precisely where the *Essayons* was discharging material in 2001, and where the majority of the mound that was subsequently re-dredged occurred.

re-dredging was chosen without discussion about other potential actions, may reinforce erroneous public perceptions concerning:

1. whether Site E was in fact "out of compliance" with the Settlement Agreement (which is questionable);

2. if it was, whether it created a safety hazard (which is also questionable); and

3. whether re-dredging should be expected in the future in similar circumstances.

Such public perceptions can have adverse effects not only on continued use and management of the existing disposal sites, but on future designation and management of proposed new disposal sites in the area as well.

Existing management of Site E has therefore arguably become more much restricted than required by the Settlement Agreement. At virtually every step in the management and decision trail, conservative approaches have been followed. The 10 percent standard is being measured – or rather *indicated*, since direct wave monitoring is not being done - by conservative metrics (the single 5-foot depth change coupled with the RCPWAVE model). Any exceedance of these conservative indicators is being considered excessive, and to imply unacceptable risk to vessels, without any information to support that an actual hazard would result. Finally, it has been taken to indicate the need for the most drastic management response – re-dredging – if a substantial exceedance appears (by conservative measures) to have occurred. Given the limited capacity of the other existing disposal sites, these somewhat self-imposed restrictions at Site E could result in insufficient disposal capacity for maintenance of the federal channel at the MCR, particularly in years with higher than average shoaling.

4. Need To Update The MMP

The Review Team strongly recommends that the District and EPA Region 10, working closely together, re-evaluate and update the existing MMP for disposal sites used to maintain the MCR project. (EPA was not a sufficiently engaged participant in the chain of events during 2001. Since there are implications to the existing 102 sites E and F, and particularly to future EPA "102" designations, Region 10 should be much more actively involved in any management decisions concerning use of the ocean disposal sites in the vicinity of the MCR (see the Communications section below). Improvements can be made that we believe should be in full compliance with the Settlement Agreement while it remains in force, while still providing for more flexible management, a potentially greater disposal capacity, and no significant increase in risk to vessels transiting the area.

The joint EPA/USACE re-evaluation and update of the MMP should:

a. Be based on an explicit confirmation and articulation of how the various site management goals and public interest factors (including slowing erosion of Peacock Spit, slowing erosion of up-coast beaches, minimizing

impacts to Dungeness crab, not unacceptably increasing navigation risks, and maintainingsufficient capacity for necessary dredging operations) are being balanced

b. Include a clear federal (USACE/EPA) interpretation of the specific requirements of the Settlement Agreement (while it remains in force)

c. Include specific, agreed upon monitoring principles, methods, and measures that are relevant to the management goals (and Settlement Agreement requirements)

d. Continue to follow a Tiered approach that directly relates to specific site performance predictions and evaluation questions

e. Specify the kinds of management actions that could be triggered in different circumstances

f. Reflect the resources in each agency that are realistically available to carry out the site management plan

Possible management actions that could be triggered in different circumstances range from "no action", to more intensive evaluation or more frequent monitoring, to modifying the disposal plan (e.g., by "rotating" placement zones), to institutional controls (such as publishing temporary/seasonal warnings to small vessels, or establishing a web camera showing real-time wave conditions at the MCR), to re-dredging as a worst case. We acknowledge that the range of actions is broad and the possible circumstances that could indicate the need for some management consideration are essentially infinite. A prudent, adaptive management approach includes retaining enough flexibility to respond appropriately to changing conditions. We therefore recommend the management plan list the kinds of actions that would be considered, but that it not be overly prescriptive.

More intensive versus less intensive site management approaches. The final point regarding agency resources in the list above is central to the kind of management approach that can realistically be applied at the MCR. There are logically two main approaches that can be taken (with a range of modifications and permutations possible between the two). The first approach would have as its primary goal maximizing sand retention in the near shore littoral system, through intensive management of disposal at Site E and the Jetty site. This approach is the most resource-intensive. It includes using all available means to maintain detailed, real-time operational control of dredged material disposal. This means, for example, combining detailed pre-disposal planning, high-resolution disposal placement tracking and reporting for all dredges, frequent condition surveys, rapid survey data processing and decision making, and timely communication of any needed changes back to the dredges. Timely coordination with EPA and stakeholders should occur throughout the process, and redundancy in staff technical capabilities should be available at each stage. Although resource-intensive, such a system is necessary to provide for the maximum volume of material to be placed at these two dispersive sites over the course of the dredging period, while remaining within

whatever specific management parameters (bottom depth, mound dimensions and persistence, etc.) have been established.

The opposite approach could be necessitated if agency resources were the primary limiting factor. If the kind of real-time adaptive management discussed above is not possible, less material could be reliably placed at Site E and the Jetty site while remaining within the site management objectives established. For example, capacity for the season could be based on the pre-disposal condition survey only, and the dredging specifications and orders would be written accordingly ahead of time and not changed. The ability to place additional material, equivalent to that which erodes from the sites during the dredging season, would be lost. Therefore less sand would be retained in the near shore littoral system, and greater reliance would have to be placed on the limited capacity at Site F (until new 102 sites are designated by EPA). This could potentially mean that insufficient aquatic disposal capacity would exist to fully maintain the authorized dimensions of the MCR federal channel, especially in a heavier than average dredging year. However, even under this approach, we believe that re-evaluation of the specific management practices and measurements at Site E could allow somewhat more material to be placed there than would otherwise be the case.

E. Communication

Good communication and efficient information flow, both internal and external, is always important. But the need for full and efficient communication takes on far greater importance where intensive management is necessary to achieve goals. The competing objectives for operation of Site E have established the need for intensive management. In many ways, communication within the District, and between the District and its external stakeholders, is already good. However, improvements can be made to both internal and external communications to help ensure that the management goals at Site E can be successfully achieved.

There were several points during 2001 when problems with communication and information flow affected management at Site E. (These are separate from problems noted elsewhere concerning information *collection*, such as the frequency of condition surveys.) The Review Team recommends that the District, and EPA Region 10 as appropriate, evaluate any structural or organizational issues that may have contributed to these communication and information flow problems, and develop means to address them.

1. Internal

- The District did not communicate specific placement locations to the USACE dredge, as it did for the contract dredge, leading to different placement approaches being used by each

- The District did not require the placement data collected by the USACE dredge to be reported back, leaving District staff unaware that focused placement was occurring

- There was a substantial delay before the first during-disposal condition survey was provided to appropriate staff for further processing

- The lack of a written or detailed plan outlining the kinds of management actions that should be considered in various mounding scenarios, contributed to poor communication between technical staff and upper level management, particularly after media and political pressure became more intense following the *Miss Brittany* accident

2. INTERAGENCY EXTERNAL

- The District did not always clearly recognize the distinctions between actions and authorities at the EPA-designated "102" portion of Site E, versus the expanded "103" portions of the site; therefore they did not always coordinate sufficiently with EPA Region 10

- The MCR is not necessarily a high priority area for application of EPA resources, the way it is for the District; Region 10 staff have not been available to coordinate with the District to the extent necessary under an intensive management approach to Site E

- Region 10 was unaware of the actual volume of sand placed at site E until interviewed by the Review Team

- Although Region 10 concurred in the re-dredging ROD, there had been insufficient coordination leading up to the ROD, and insufficient time available at that point, to fully consider implications of the action or of the ROD language to ongoing management at Site E or to future 102 site designations

F. Wave Modeling

The characteristics of nearshore water waves depend on the characteristics of deep-water waves arriving from offshore, local wind, bathymetry, and currents. Hence, changes in water depth change wave characteristics. Portland District adopted a well-known, monochromatic wave model, RCPWAVE, to examine the potential that waves might be amplified by placement of dredged material in MCR disposal sites. The choice of which model to use and the methodology of evaluation are reasonable choices for initial testing of whether the vague criterion given in the Settlement Agreement (SA, Section D-2) is likely to be exceeded.

The SA criterion is vague because it makes no reference to how the change in wave amplitude is to be determined. Is the baseline for definition of change referenced to the pre-disposal depths for the year in question or for some other condition? It is not practical to measure wave changes directly over the areas of concern. So, presumably the planning and verification that thresholds were not exceeded has to be based on modeling with perhaps some short-period spot measurements. Yet the SA does not specify how

this modeling is to be done. Neither is any definition given of what would constitute exceedance in terms of the conditions, area, or time for which the waves are to be evaluated.

1. RCPWAVE MODEL

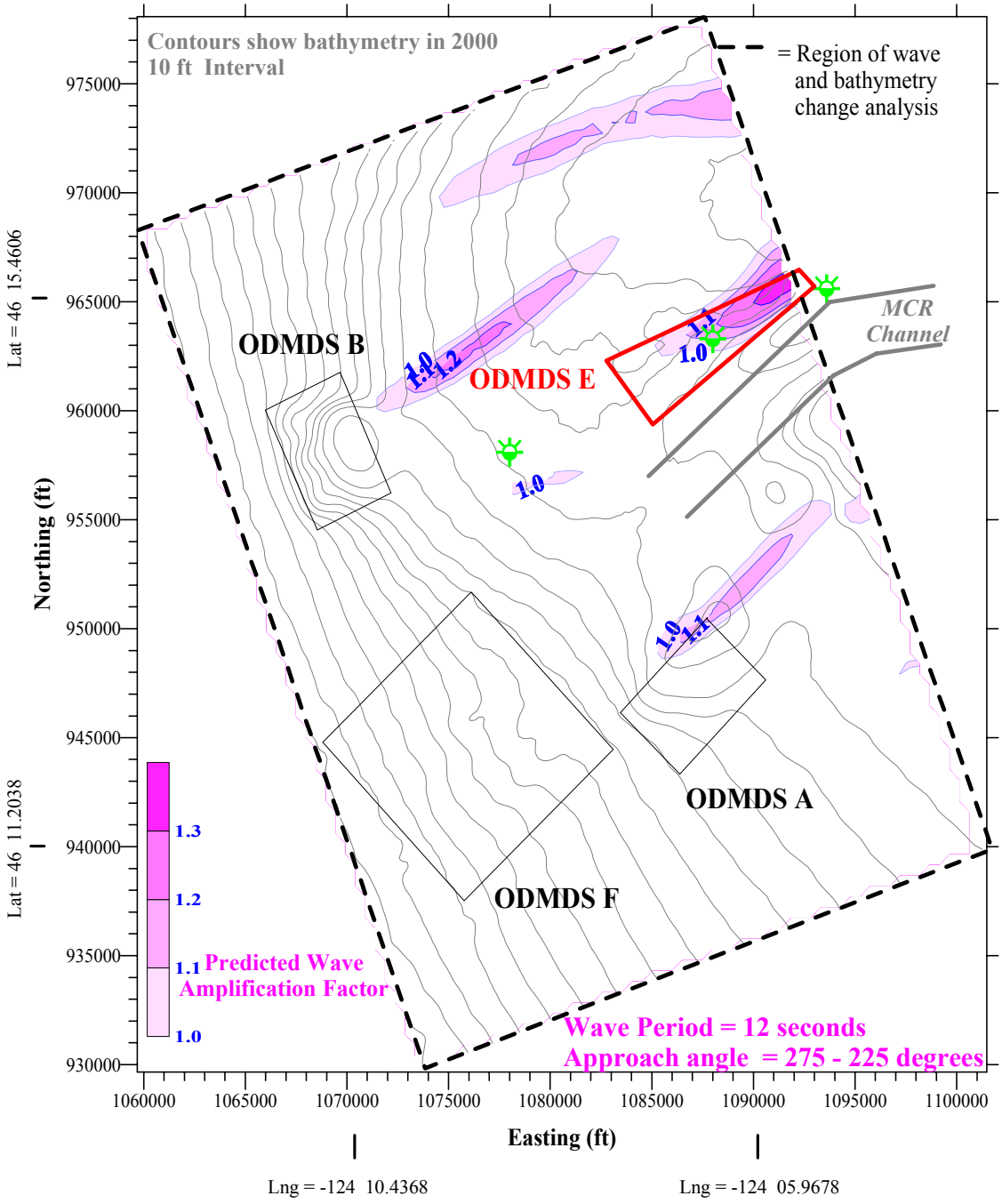
RCPWAVE (Ebersole 1985; Ebersole, Cialone, and Prater 1986) is a monochromatic wave transformation model. The wave field is composed of uniform waves, i.e., all of the same height, period, and direction. RCPWAVE is a widely used engineering tool that calculates evolving wave characteristics (height, period, and direction) as a wave propagates out of deep water, moves shoreward, and finally breaks in depths equal to about the height of the wave. Wave characteristics within the model vary in space, but not in time. The theoretical basis for RCPWAVE was established in the 19th century, but linear wave theory is still the most widely used theory for many engineering applications including operation of wave pressure gauges, and estimation of rates for alongshore sand-transport and shoreline change. RCPWAVE overcame problems with earlier wave ray refraction models that failed where waves appeared to cross in areas of nonuniform bathymetry like Site E.

There are more sophisticated, time-dependent, shallow water spectral models that better represent more extreme refraction and diffraction and other features of wave transformation. These later models are required if results are to approximate mechanisms like wave reflection. wave-wave interaction, nonlinearities, steep bottom slopes, wave-current interaction, input of wind energy, and the nonunifomity of waves in height, period, and direction. Models that consider these complexities require denser numeric grids, greater computer resources, and more experienced interpretation. Such requirements presently make the more complex models generally beyond routine management use. Furthermore, RCPWAVE usually overestimates the increase in wave height (Smith and Harkins 1977) that occurs as a wave moves into shallow water. Thus RCPWAVE is conservative and appropriate as a screening tool to identify thresholds for concern in situations like Site E.

2. STWAVE MODEL

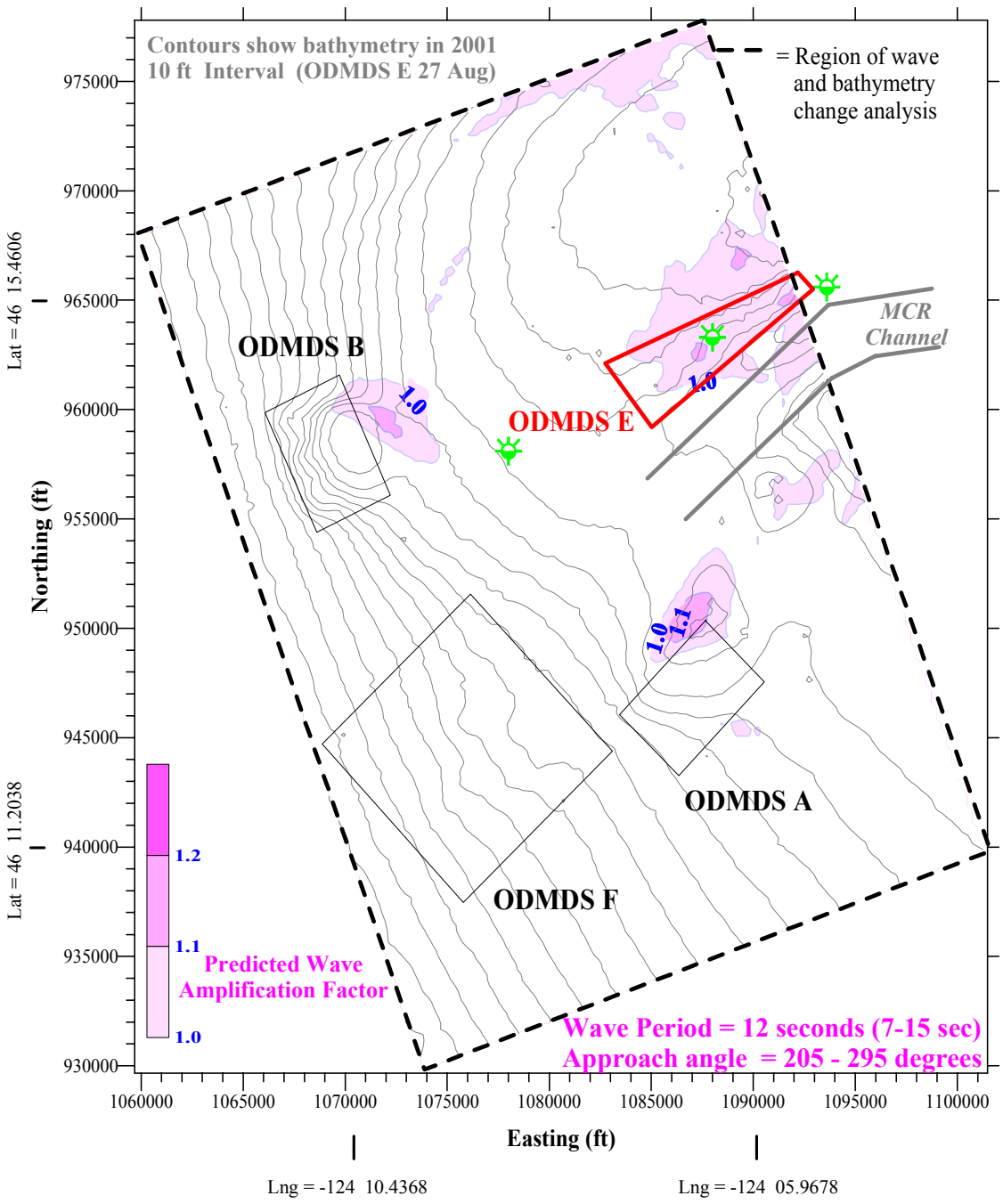
STWAVE (Resio 1993) is probably the most widely used of the more sophisticated PC models. STWAVE goes beyond RCPWAVE by including bottom friction, percolation, wind input, and nonlinear transfers of energy. This last feature makes the results more realistic especially over complex bathymetry, like Site E, were monochromatic models over estimate the focusing effect of the bottom. Examples of the differences can be seen by comparing RCPWAVE results with STWAVE results (Figure 11). The over focusing of energy by RCPWAVE is not as apparent in figure 11 as would otherwise be the case because many results from rerunning RCPWAVE for a large number of wave directions and periods have been combined ad hoc to produce a single picture of amplification much as repeated film exposures can capture a single image of many situations. NWP developed this method of overlapping monochrome wave results as an improvement in applying RCPWAVE to estimate whether the accumulation of placed material was causing significant wave amplification.

STWAVE can also handle wave-current interaction and wind input, but these features were not applied when obtaining STWAVE results for comparison with RCPWAVE. Figure 12 is a representative example comparing NWP's standard RCPWAVE results with STWAVE results obtained at ERDC in September. Including realistic estimates of wave-current effects would have changed the results substantially. Waves steepen when opposed by a current. In this case ocean waves are steepened by ebb currents and flattened by flood currents. This fact is well known and the basis for avoiding the bar during ebb tide when seas are high.



RCPWAVE Model Results Figure 15

Figure 11. RCPWAVE model estimate of potential for increased focusing between 1997 and 2000 (Figure and modeling by NWP).



STWAVE Model Results

Figure 12. Spectral estimate of potential focusing for similar conditions as input to monochromatic model shown in previous figure. Amplification shown here are for all waves input to RCPWAVE and in addition to waves from more southerly and northerly sectors. In spite of the additional waves, STWAVE does not indicate amplification as intense as RCPWAVE. The contours shown are for 2001, but the bathymetry input to both models was identical (nominally 2000 and 1997)

3. Limited Area of Influence

The amplifications shown in Figures 11 and 12 are due to natural and dredge-related bathymetric changes. Figure 11 shows four large areas of change. It is safe to say that all but the most northerly of these amplification areas are due to dredged material disposal. The most landward of these three areas occurs because of the material placed in Site E between 1997 and 2000 . The other two are because natural changes eroded southern sides of the prominent dredged material mounds at Sites A and B and moved this material to the north over this same period. The lateral extent of amplification tends to be exaggerated by RCPWAVE. Note, however, that disposal in E created a potential for amplification above 10% that extends no more than 2500 ft outside of Site E. Natural accretion on the north portion of Peacock Spit created a potential amplification area much larger than did the bathymetric changes in Site E. In the longer run, the purpose of returning sand to the littoral system is to reduce erosion of the sub-aerial beach and the submerged portion that supports it. Over many years, as tens of millions of cubic yards of sediment are kept in the littoral system, the hope is that this action creates a significantly wider shore than would be the case if dredged material were taken out of the littoral system. We do not expect these much larger changes will create any boating hazard because safe navigation requires awareness of actual sea conditions, not hypothetical ones that would have existed if erosion had proceeded unchecked.

4. Recommendation to Detach Considerations of Wave Modifications from Dredged Material Disposal Decisions

Problems with Increasing Wave Height. A finite amount of wave energy arrives inshore from deep water. Through interaction with the bottom, the wave properties are transformed as energy propagates shoreward. In the present context, it is important to recall a fundamental principal, different bottom configurations rearrange the spatial distribution of wave heights across the nearshore zone. Waves peak over certain (shallow) areas and diminish where wave breaking dissipates energy. Wave heights also decrease in areas that are deprived of the energy that is focused instead onto shallows. Wave height changes depend on the exact bottom configuration, but the wave energy flux summed across the whole nearshore zone is never amplified by interaction with the seafloor regardless of how shallow, deep, or rough. At locations where energy is focused, wave heights increase and in adjacent areas, heights decrease. The simultaneous combination of wave amplification/reduction can be seen, for example, in Figure 13.

Vague SA Condition, Difficult To Measure And To Model. Even if there were only a single wave height, period, and direction in deepwater, the irregular bathymetry of Site E would create varying wave conditions across its surface. It is not practical to measure continual variations over an area the size of Site E even at much less energetic field sites. Even for research purposes, field measures would be few and modeling would be employed to interpolate spatial variations. There is no unambiguous method to determine if the SA criterion is exceeded because there is no specification of the exact location and

size of the area where modeled waves must be large, for what time span, by what model, what modeling procedure, and for what bathymetric, wind, tide, and incident wave conditions. In each case where these ambiguities suggest different interpretations, the District choose to follow the conservative interpretation that favored minimizing wave changes even when that interfered with other disposal objectives. The following subheadings summarize further problems in applying the SA wave amplification criterion even if its vagueness were to be reduced.

Multiple theories. Engineers use a hierarchy of wave theories. To varying degrees all theories are simplifications of known real world variations.

Multiple models. Models used to apply each theory add an additional layer of abstraction or idealization. Figures 11, and 12 illustrate the magnitude of differences obtainable with just two of many possible models. RCPWAVE does not model as many features of wave transformation as does STWAVE and typically over estimates the height of refracted waves as seen in Figure 11.

Model input uncertainty. Wave height at a given time and location is a function of several usually poorly known independent variables some of which change substantially with time:

(a) 3-D bathymetry (not just scalar representation of depth).

(b) Simplified incident waves (rather than range of sea conditions).

(c) Wind can modify the wave directly and through wave current interaction.

(d) Tide has a major effect of wave height, length, speed, and steepness.

(e) Wave-wave interaction.

Most coastal engineering applications allow modeling errors exceeding 10 percent and compensate for them with conservative margins of safety. The SA's focus on 10 percent wave amplitude has complicated dredging and has questionable actual benefits for safety.

Incompatible Objectives. Dredging is the primary tool that Corps uses to provide for safe navigation. Through a long process, involving work by many agencies and other public representatives, Site E was designated a disposal area for dredged material. Dredging of disposal areas is prima facie evidence of disposal area mismanagement. In the case of Site E, this alleged mismanagement seems to be a direct result of attempts to compromise two contradictory uses. Deep-water sites can be managed to meet simultaneous navigation and disposal uses at the same time. The value of Site E, however, is that it is located where vigorous waves and currents will disperse the placed sediment, returning it to the naturally dynamic prism of beach sand.

If the volume of dredged material placed in Site E were to be restricted based on a requirement not to change wave patterns, then no sand should be placed in the authorized disposal site. In other words, any use of the Site will change the bathymetry and thus alter the wave transformations to some degree temporarily. Therefore, the claim could be made that the inevitable future boating accidents in this hazardous area would not have occurred except for the disposal that either elevated or at least reshaped the seafloor. A logical counter argument would be that prudent boat operation requires that the skipper respond to actual, not hypothetical, wave conditions and that frequently the response would be to avoid Site E regardless of whether dredged material had been placed there or not.

During storms natural sand movement can cause elevation changes in excess of 20 ft (Hands, 1999). Build up of the seafloor caused by placement of dredged material over a full dredging season at Site E has not occurred. Skippers must be ever vigilant in this region *because large and steep waves cannot be predicted.*

Compromised Channel Maintenance. We have discussed the need to not reduce options to place material in Site E. Actually, greater than past use of Site E seems necessary, along with designation of the Deep-Water Site and exploration of ways to place sand directly on adjacent beaches in order to maintain the practice of dredging 3 to 5 M cy from the entrance annually. These options are discussed further in a later section.

Limited Measure of Boating Hazard. The SA limitation, that dredged material placement not result in more than a 10% wave amplification, was accepted to help resolve a lawsuit brought against the Corps by the CRCFA. The CRCFA were concerned about potential increased risk to boats in the vicinity of Site E. Interviews and documents indicate that NWP initially felt this criterion would not limit their use of Site E nor have an adverse impact on their ability to maintain safe conditions in the MCR navigation channel (e.g., U.S. Army Engineer District, Portland. 1998). Through a series of modifications and reinterpretations (and loss of alternative placement sites) the SA led to adoption of a depth change threshold, then a depth change limit, a management decision to dredge Site E, and finally to a management policy that significantly limits dredging options and, it seems to us, threatens continued maintenance of the navigation channel.

Not only did the SA led to a situation jeopardizing safe channel maintenance by restricting disposal options, but also it offered no objectively measurable risk reduction for vessels choosing to traverse Site E. There are several ways Site E placement criteria could be changed that would permit placement in Site E while limiting any increase in hazards to boats in the area. Better placement criteria could eliminate vagueness. The criteria could be directly related to changes in hazard seas for specific areas. Standards for applying the criteria could be developed that would permit objective identification of whether the criteria were met or violated.

If, however, a decision is reached that tolerates no increased hazard at any time for boats traversing Site E, then there is no way to prove that placement of any amount of material, no matter how small, does not violate this strict limitation. Placement raises the

bottom elevation. In such a shallow location as Site E, raising the bottom will modify wave characteristics and among other things increase the wave height and steepen waves.

Real Hazard on Peacock Spit. The large natural shoal off MCR is Peacock Spit (Figure 10). It is a chronically eroding remnant of the pre-jetty ebb shoal. Ebb shoals are naturally occurring deposits that occur at inlets and estuary mouths wherever tidal and wave forces oppose one another. They usually take the form of a crescentic bar. For most of the last century the former ebb shoal has been eroding (Figure 10) creating deeper water to the northwest of MCR. The deeper water allows larger unbroken waves to impinge on the tip of the North Jetty. Damage to the jetty is increasing not only because of greater wave exposure, but also eventually because of undermining as the jetty foundation becomes threatened. If unchecked erosion would eventually provide deep water and thus might appear to offer future improved navigation conditions for boats turning north just beyond the jetties. Disposal in Site E slows these processes, but helps maintain jetty stability. Under present conditions and even if erosion of Peacock Spit proceeds to the point of jetty collapse, the hazardous wave conditions for boats taking a shortcut to northern areas would not be encountered in Site E, but a mile or more to the north on Peacock Spit as illustrated by the large area of wave breaking shown in Figure 14. Our other wave-related figures shows changes in wave conditions compared to 1997. Figure 14, in contrast, shows actual as well as changed conditions. The modeled waves did not break in Site E in 1997, but did along a small portion in 2000. In both years, however, there were large areas of breaking to the north. This breaking was not a direct result of any disposal (Figures 11 and 12). If a vessel were to avoid the large area of breaking on Peacock Spit, Site E could also be avoided with little or no added transit time to or from nearshore areas to the north.

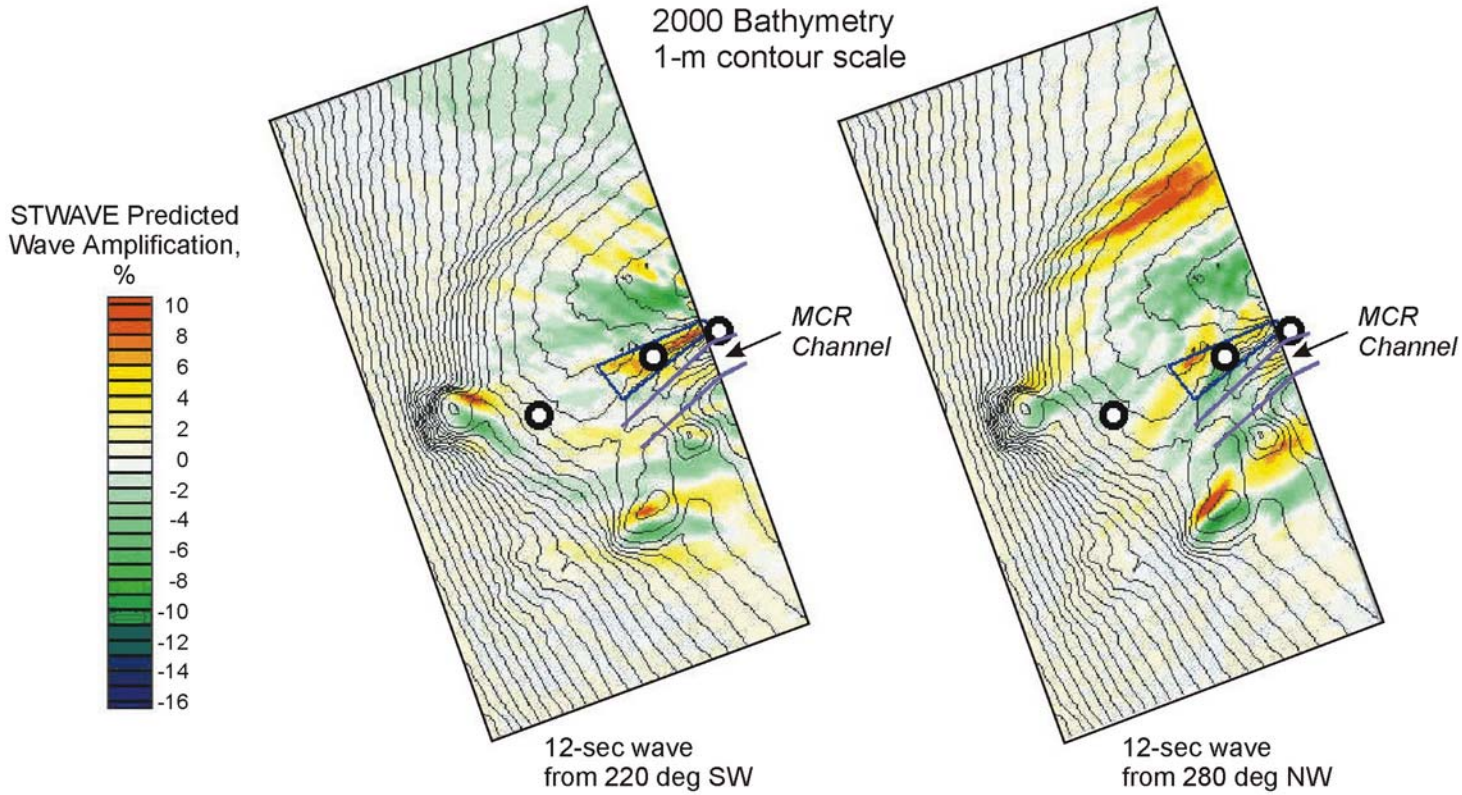


Figure 13. Model results of where wave heights increase and decrease for a particular incident wave field and bottom configuration.

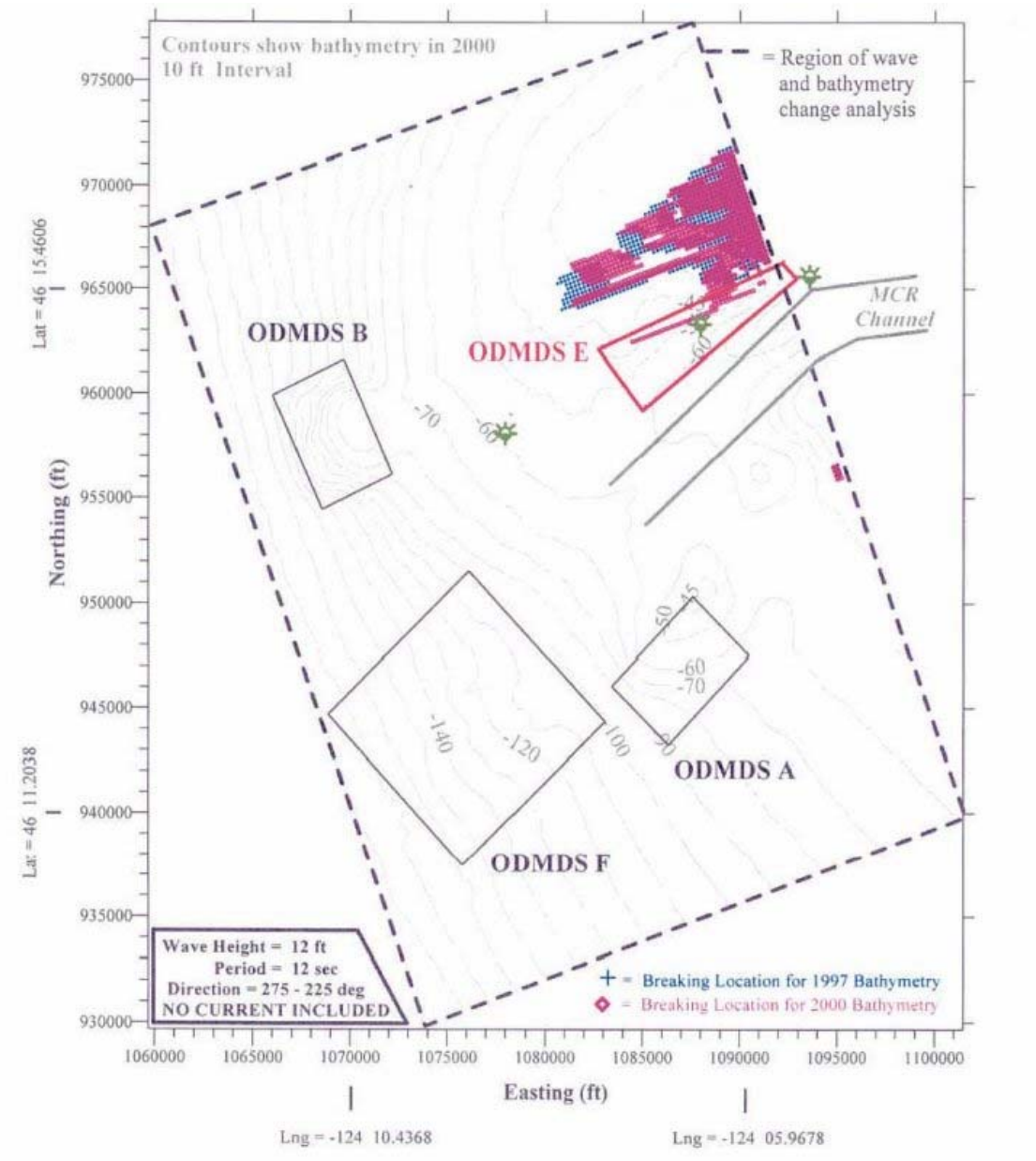


Figure 14. Predicted areas of wave breaking in 1997 and 2000.

5. Recommended Review Of Site E Objectives

Assurance that disposal contributes in no way to the danger of traversing Site E, would probably mean abandoning any use of the site. Therefore we see only limited realistic disposal options that have no potential to impact safety, serve navigation needs, and meet environmental goals (Table 1).

Table 1
Dredged Material Disposal Options, Considered In Combinations In Text

Number	Option	Estimated Annual Capacity, Mcy
1	Site E with strict requirement of no increased hazard to boats	0
2	Site E with no requirement based on hazards to boats in the vicinity	3-4
3	Site F	1
4	North Jetty Site	0.5
5	Deep-Water Site	> 6
6	Pumping onshore	> 2
Only the first four are presently available, designated sites.		

At least 5 of the 6 options have been addressed in the recently completed EIS (USACE 1999). The EIS considered direct beach placement, but concluded it was too expensive. Considering the limited disposal options and the well-founded forecast of increasing erosion throughout the Columbia River Littoral Cell, it is only prudent to look closely at new options for retaining valuable sand onshore. Options should include innovative designs benefiting from new technology (e.g., the Punaise, Williams and Visser 1998), cost sharing, economies of scale, special allocations with long-term amortization of investments based on knowledge of long-term and growing needs to conserve limited sand resources. From a regional sand management perspective, additional costs to beneficially use dredged material could be much cheaper than late remedial action. There is, in any case, insufficient technical data to make a comprehensive analysis of costs and benefits associated with all promising options. Resolution of competing uses is always difficult, but especially so at MCR where the well articulated desire for safe boating over Peacock Spit directly contradicts its functioning as a designated disposal and beneficial use site.

Resolution of conflicting uses usually requires either a command decision or difficult and lengthy discussions with all interested stakeholders. Without second-guessing the outcome of either approach, the major advantages and problems with each option are summarized in Table 2.

As an alternative to compromising two diametrically opposed goals (use of Site E and boating safety in a shallow hazardous location), investigating whether there would be other supportable ways for the Corps or other agencies to help reduce boating accidents in the vicinity of Site E while its use as a disposal site continues. Modification, even

elimination, of Site E use might arguably have a minute positive effect, but it could also be argued that this would encourage risky traversing through a dangerous area. In his testimony, Captain Neal Nyberg, Master of the *Essayons*, volunteered that whatever the conditions in Site E, they are always better in Site E than farther north on Peacock Spit.

One example of more effective measures to reduce risk for those fishing Peacock Spit would be to maintain some mechanism like web-reporting wave and current gages and/or video cameras that would provide information of sea conditions that could be assessed remotely. The feasibility of modeling to develop forecasts and nowcasts of sea conditions, wave steepness, and/or probability of sneaker waves are other examples of steps that might be taken to improve boater safety.

Table 2
Major Advantages And Disadvantage Of Disposal Options

Number	Abbreviated Option	Advantages (+) and Disadvantages (–) under present arrangements
1	E, No wave amplification	+ Reduced liability exposure for boating accidents, but no less real hazard. - Loss of disposal site and erosion mitigation.
2	E, Without wave-based limitation	+ Beneficial and efficient use of DM. + Likely to diminish rate of Peacock Spit erosion - Exposure to liability for future accidents
3	Site F	+ Backup disposal site for maintenance and capacity for deepening. - Irrecoverable loss of sand resources. - Congestion between dredge, waiting pilot boats, and channel traffic. - Limited capacity
4	North Jetty Site	+ Proximity to channel shoaling. - Limited capacity
5	Deep-Water Site	+ Backup disposal site for maintenance, retention of any sediments unwanted near shore, and capacity for deepening. - Irrecoverable loss of sand resource. - Not presently designated.
6	Pumping onshore	+ Direct beach erosion mitigation. + Potential for all-weather disposal, short haul, and flexible beneficial use. - Costs and permits have not been evaluated. - Does not likely diminish rate of Peacock Spit erosion.

The primary recommendation of this team is that the objectives of Site E usage be reevaluated with the recognition that wave amplification limitations do not make traversing the Site significantly safer, but do severely hinder beneficial uses. There is a need for better articulation of where within the site specific elevation changes are important. Further, definition of lateral extent of such changes also needs to be considered. The long-term strategy of MCR dredging operations should be revisited with all stakeholders including the CRCFA as parties interested in preservation of crab and other natural resources.

The following section summarizes observations and conclusions about laudatory aspects of Site management as well as suggestions to modify certain procedures even before overall Site objectives can be clarified or redefined. These recommendations, given in more detail earlier in our report are intended to provide such benefits as increased coordination within NWP and with EPA, earlier and more objective warnings that new placement thresholds are being approached or exceeded, and broader

understandings of the responsibilities and appropriate responses when and if thresholds are exceeded.

V. Summary of Observations and Recommendations

The Review Team makes the following observations and recommendations based on the information we evaluated during our investigation. It is important to note that this report does not address any aspect of causality for the vessel accidents that occurred during the summer of 2001. The Review Team did meet with the US Coast Guard in the course of our investigation to exchange information, but the conclusions of that investigation will be presented in an independent Coast Guard report.

- District and EPA staff are doing a very good job of trying to balance the conflicting site management objectives (e.g., maximum beneficial use, avoidance of mounding and avoidance of the western portion of Site E after August 15th), but this balancing is not explicitly written.
- The District effectively uses many lines of communication providing multiple opportunities for discussion and feedback by all interested parties.
- Frequency and level of involvement with EPA on Site Management decisions needs only minor, but critical improvement.
- The disposal practice used by the *Essayons* in 2001 may have unexpectedly resulted in the mounding observed in the eastern section of the site. Even though disposal primarily occurred in a small, energetically dynamic portion of the site, this likely lead to the mounding observed nearby.
- The Corps dredge crew is knowledgeable of the site management goals and conducted their portion of the work in a way to try to meet these objectives.
- District staff were unaware of this disposal pattern because placement positions were not mapped and reported back to managers and there were significant time delays between surveys and difference plots after completion of surveys.
- The management of sediment placement by Corps dredges needs some improvement.
- The management of sediment placement by contractors is generally well managed.
- The District should include in both Dredge Orders and Contracts specific measures to insure that disposal release points or lanes are appropriately distributed to help avoid mounding and require reporting of sediment release positions in a timely manner.
- The District should take steps to assure that critical tasks (e.g., bathymetric survey difference comparisons) and capabilities have redundancy among the staff and that tight reporting requirements be developed .
- The District should build more deliberate site alternation (e.g., between Sites E, F, and North Jetty) into the annual disposal schedule to provide time to collect, process, and evaluate monitoring data as well as time for natural dispersion of sand off the site during the dredging season. For

example, Corps dredge placement could be limited to a specified volume at Site E whereupon sediment would be directed to North Jetty until a survey of Site E had been conducted and reviewed. Then, based on that information a new interim volume could be allowed at Site E before triggering another survey.

- The District should develop a more realistic approach to initial calculation of capacity available at Site E given that portions of the site are sometimes effectively not available to disposal.
- The District and EPA should develop potential management responses/contingencies to monitoring results relative to site limitations. This could be done by developing Tier 2 and possibly Tier 3 of the monitoring/management approach. This will create better advance coordination with EPA and will also create clearer procedures and potential responses when quick decisions are needed.
- There appears to be good respect and trust between the EPA and the Corps, though the District should consider steps (e.g., training/partnering between different management levels) to increase it.
- The District should lead the development of a joint USACE/EPA understanding of the Settlement Agreement to be concurred with by upper management of both agencies.
- The District should take steps to ensure that there is an understanding throughout the entire management chain of the difference in site authorities, responsibilities, and final decision roles for MPRSA 102 and 103 sites, and how this affects joint management responsibilities and coordination needs is very important.
- The District should assure that EPA is explicitly involved in decisions about seasonal placement volumes at the 102 designated sites.
- Site Management discussions between EPA and the District (at all management levels) should always include the District Ocean Dumping Coordinator.
- Staff, resource, and priority levels at EPA appear to adversely affect both the interagency communication (written and verbal) and the progress on long term disposal site needs. The District should take steps to discuss this with EPA management.
- The District should work with the Coast Guard in developing some real time measurements of sea conditions at the Mouth of the Columbia River especially near the north Jetty and west toward Site E. This would assist the Corps and contract dredges as well as the general public transiting the MCR. One suggestion would be the creation of a real time web site which could include the wave height, picture off jetty, and tide information.
- The District should consider dedicating a survey vessel to Site E during the critical stages.
- The District needs to reevaluate the use of sand bypass systems as one alternative to the use of Site E.

- The District and EPA should, as soon as possible, update the existing MMP. The update should incorporate, as appropriate, the preceding recommendations.
- The District and EPA should proceed, as soon as possible, with designation of new permanent ocean sites capable of meeting the long-term disposal needs of the MCR project.

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